Forestry & Agriculture Review 2(2), 2021 **ISSN 2693-0269**

Effect of Different Types of Substrates on the Growth and Development of *Khaya Senegalensis* (Desr) A. Juss

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Doi: https://doi.org/10.47285/far.v2i2.102

Citation: Coly, I., SONKO, B., FATY, M., & BODIAN, S. (2021). Effect of Different Types of Substrates on the Growth and Development of *Khaya Senegalensis* (Desr) A. Juss, *Forestry & Agriculture Review*, 2(2), 1-13. Doi: https://doi.org/10.47285/ far.v2i2.102

Research Article

Abstract

In Senegal, Khaya senegalensis is subject to abusive and illegal exploitation, thus compromising its regeneration and the survival of its natural stand. It is in this context that this study aims to contribute to the reconstitution of Khaya senegalensis stands through the production of information allowing an optimal production of seedlings of this species in the nursery. The chosen device is a device in randomized complete blocks or Fischer blocks with 3 blocks or repetitions. Each block has 10 treatments with 20 sheaths each. The parameters studied are the height of the plants, the diameter at the collar, and the number of leaves of each plant. The analysis of the results obtained indicates that the greatest average plant heights were recorded with the compost (C) and the sand+compost (SC) treatments with 12.71 cm and 12.25 cm respectively. The lowest average heights (6.7 cm) were observed with sand (S) and sand mixed with potting soil (ST) with heights of 6.7 cm and 8.91 cm respectively. The largest diameter at the collar of Khaya senegalensis plants was obtained with the sand compost substrate (0.38 cm) and the smallest (0.25 cm) was observed with the sand substrate. The lowest leaf production is noted on the sand substrate alone (4.6 leaves/plant). However, it seems appropriate to continue this study by evaluating the effect of different types of pretreatments on the germination of Khaya senegalensis seeds in order to establish the basis for rapid production of Khaya senegalensis seedlings in the nursery.

Keywords: *Khaya senegalensis*, substrates, growth, development

1. Introduction

The continuous degradation of the vegetation cover in West Africa is partly due to the strong anthropic pressure linked to the high demographic growth and climatic factors (Ehui et al, 1989; Wezel., 2006; Bamba et al, 2010). Indeed, the loss, fragmentation and modification of species' natural habitats due to land overexploitation, wildfires, and overgrazing are the most important factors in the impoverishment of species diversity (Hargitt, 1994; McNeely, 1996). In addition, logging, one of the main sources of income in the economy of many African countries including

Senegal, now leads to the degradation of several forests and natural habitats as well as the rarefaction of many species (FAO, 2005) cited by Bamba (2018). To these factors are added pollution and climate change (Sala et al, 2001). As a result, this degradation has resulted in an erosion of biodiversity with the corollary of the rarefaction of many species in their natural habitats. In the southern Sahara, more than two hundred forest plant species are considered extinct (Hilton-Taylor, 2000). *Khaya senegalensis*, already on the IUCN Red List, is one of the most overexploited species due to its multiple uses. It is in critical danger of extinction in Benin (Adomou, 2005). Thus, its situation remains worrying and deserves special attention. It constitutes, in addition to *Pterocarpus erinaceus* Poir, Tectona grandis L.f. and Gmelina arborea Roxb. the main timber-producing species in Senegal (ISRA, 1993).

In Senegal, its illegal harvesting and commercialization have been remarkable in some areas such as the southern sector. The seriousness of the phenomenon linked to its increasing demand on the international market shows that natural stands alone cannot satisfy the world's needs. Thus, its domestication must be perceived as an ecological, economic and social issue.

Therefore, one of the most effective ways to meet the social and economic challenges of the African continent in general and Senegal in particular is to implement a development that integrates strategies for the conservation of natural resources, particularly forests, while fighting against their degradation.

It is in this context that this study aims to contribute to the reconstitution of *Khaya senegalensis* stands through the production of information allowing an optimal production of Khaya senegalensis seedlings in nurseries.

2. Literature revew

Khaya senegalensis commonly called cauliflower is a tree that belongs to the kingdom Plantae, division Magnoliophyta, class Magnoliopsida, order Sapindales and family Meliaceae. According to CIRAD (1988), the species is native to tropical Africa, along a band roughly parallel to the equator. It is distributed on a band where rainfall is between 650 and 1500 mm spread over 4 to 7 months (Von Maydell, 1983; CIRAD, 1988). It prefers moist, deep soils, alluvial deposits, riverbanks and non-flooded lowlands (Von Maydell, 1983).

Khaya senegalensis is a tree that can reach 35 m in height. Its roots can grow to about 25 cm in length in 3 months. The leaves are pinnate with 3 to 6 pairs of leaflets; the flowers are small, about 5 mm in size, white and inconspicuous. Fruits are globose woody capsules 5 to 10 cm in diameter, which burst into 4 valves (Von Maydell, 1983).

In West Africa, woody plant species provide humans with income, edible products, traditional medicine, energy, and other aspects of human well-being (Olivier et al., 2012; Sanogo et al., 2013; Douma et al., 2019). Indeed, regarding *Khaya senegalensis* all its parts are used for the treatment of different diseases in the pharmacopoeia. The wood of the species is used in carpentry and particularly in the manufacture of mortars and dugouts (Von Maydell, 1983). Thus, woody plants and their habitats are undergoing disturbances, linked to these anthropic actions and to climate change, which threaten their survival. Among the commonly exploited and endangered species is Khaya senegalensis. It is an agroforestry tree that constitutes a very important source of income for the populations but is becoming increasingly rare in the various Sudanese ecosystems. The various anthropogenic pressures on *K. senegalensis* combined with the difficulties of regeneration give it the status of vulnerable species threatened with extinction on the IUCN red list (Adjahossou et al., 2018). The survival of this species, now, relies on appropriate management approaches associated with artificial regeneration techniques.

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3. Materials and methods

3.1. Presentation of the study area

This study was conducted in the forest garden of Koubé, in the village of Faoune. This village, located at latitude 13° 4' 33,406"N and 150° 36' 36,193"W, is the capital of the Faoune commune and belongs to the Diaroumé district, the Bounkiling department and the Sédhiou region (Figure 1).

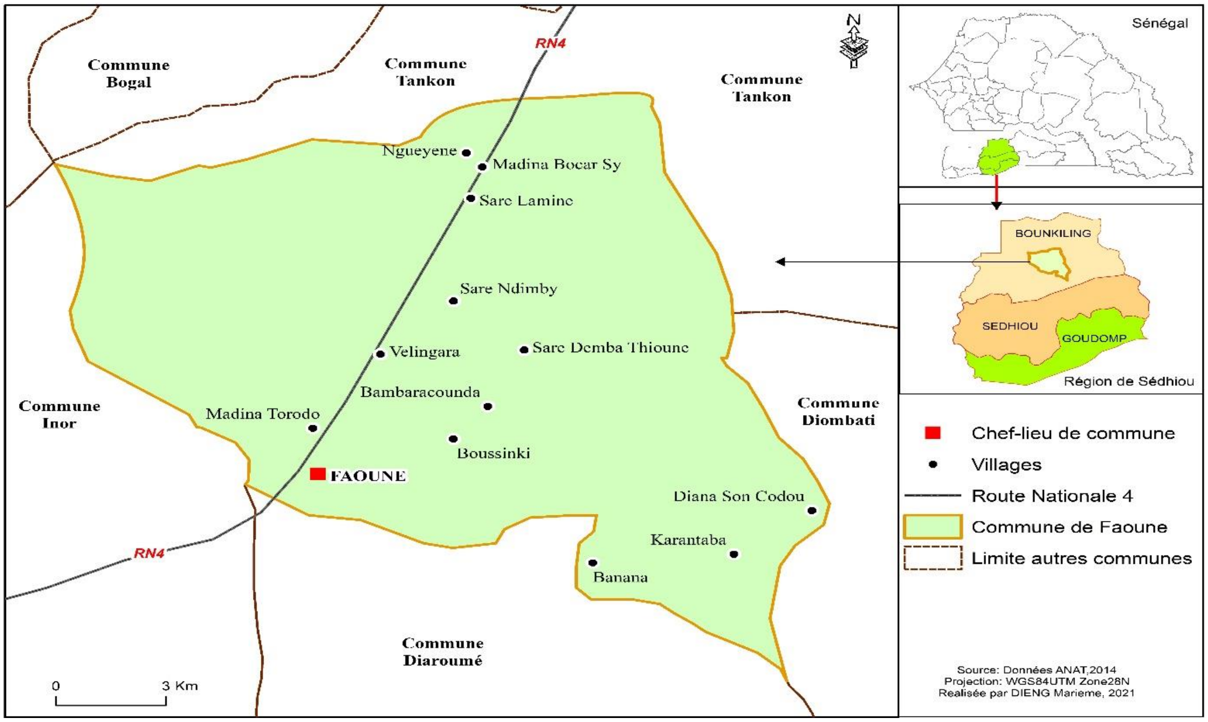

Figure 1: location map of the study area

The village of Faoune belongs to the Sudano-Guinean climatic zone with a rainy season from June to October and a long dry season from November to May. Its climate is characterized by significant rainfall with an annual average of 1100 mm (Enda Pronat ,2017). Temperatures are generally high. Annual averages range between 21°and 37°C (Charahabil et al, 2017).

The soils are either Deck-Dior type (clayey-sandy), rich in organic matter and with good aptitude for market gardening, cereal and groundnut crops, or Deck type (clayey and hydro morphic), rich in mineral elements and organic matter (Enda Pronat ,2017).

3.2. Materials used

3.2.1. Biological material

The plant material used in this study consisted of *Khaya senegalensis* seeds collected in the natural forest of Faoune.

3.2.2. Substrates

Manure, compost, potting soil and sand are the substrates used during the experiment.

- Manure

The manure used was sheep and goat dung collected at the farm (Jardin forestier de koubé) where the study was conducted.

- Compost

The compost used was produced on the farm of the Agroforestry Department of Assane Seck University in Ziguinchor. It is produced using the windrow composting technique from straw, twigs and dead leaves from mango trees.

- Potting soil

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The potting soil used comes from a plantation of *Acacia nilotica* (L.)Wild.ex Delile, a tree used in agroforestry to increase soil fertility.

- The sand

The sand used comes from sediments deposited by runoff water. It is collected in front of the farm where the study was conducted.

3.3. Methods used

3.3.1. Conduct of the trial

For the realization of this study, a nursery was installed. To do this, seedlings were made in sheaths arranged on a board at a rate of 5 seeds per sheath. And this, in 360 sheaths filled with substrates consisting of a mixture of sand, potting soil of *Khaya senegalensis* and potting soil of *Acacia nilotica*.

For the potting of the sheaths of the experimental set-up, four types of substrates (potting soil, sand, manure and compost) were brought in and mixed two by two at a ratio of 1/1 (50% for each substrate). Apart from these combinations, each substrate was brought alone without mixing. The mixing of the substrates was done with a shovel until a homogeneous lumpy mixture was obtained (photo 1).

Photo 1: mixture of different substrates

Then, polyethylene sheaths of 25 cm height, 10 cm diameter and a thickness more or less superior to 60 microns were filled from the substrates thus obtained up to the brim and then packed lightly. These sheaths were placed on elementary plots corresponding to the different treatments. Each of these plots contains 5 sheaths along the length and 4 sheaths along the width, for a total of 20 sheaths per treatment (Photo 2).

Photo 2: example of ducts filled with the different substrates

Fifteen (15) days after sowing, the seedlings obtained in the nursery were transplanted into the well-potted sheaths with different types of substrates corresponding to the different treatments. Thus in each sheath 3 seedlings were transplanted. After transplanting, a daily watering of the seedlings was carried out.

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Then, a dismating was carried out at 15 days and the most vigorous seedling was retained.

3.3.2. Experimental setup and factor studied

The factor studied is the type of substrates. The set-up used is a randomized complete block design with 3 blocks or repetitions. Each block has 10 treatments or elementary plots. And each elementary plot has 20 sheaths corresponding to a treatment (figure 2). The blocks are separated by 1 m and the treatments by 0.50 m. In total, each block has 200 sheaths, i.e. 600 sheaths for the whole system.

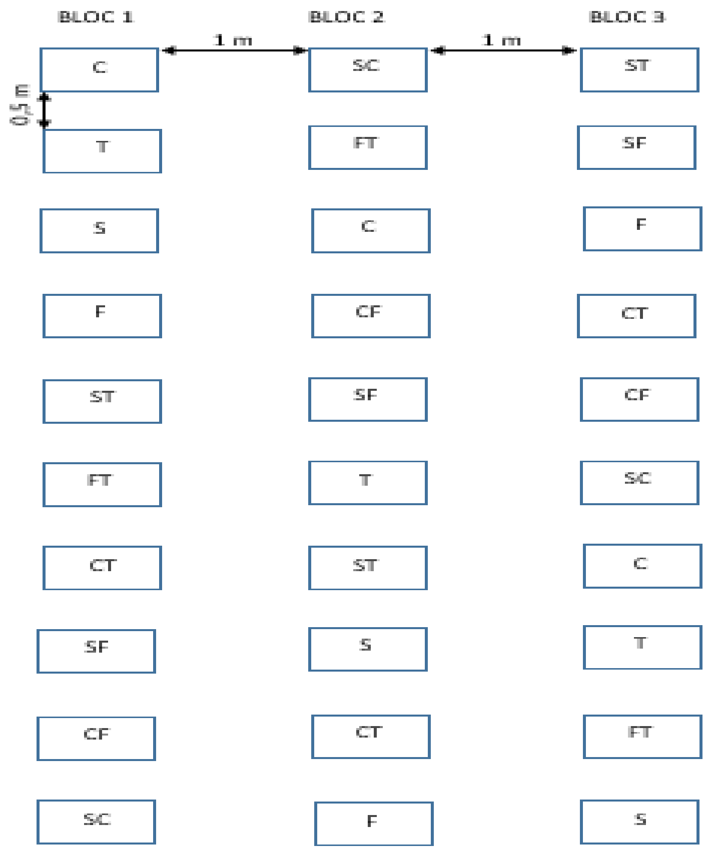

Figure 2: experimental set-up

Legend: C : Compost ; CF : Compost + Manure ; CT : Compost + Soil ; F : Manure ; FT : Manure + Soil ; S : Sand ; SC : Sand + Compost ; SF : Sand + Manure ; ST : Sand + Soil ; T : Soil

3.3.3. Data collection

Regular monitoring of growth and development parameters of *Khaya senegalensis* was carried out. The parameters monitored were: plant height, diameter at the collar and number of leaves.

o **Height of the plants**

Fifteen (15) days after transplanting (DAR), the height of 10 randomly selected plants per treatment was measured (Figure 4). This measurement was done every 15 days using a graduated ruler from the collar to the tip of the last leaf.

o **Plants collar diameter**

As for height, on the 10 selected plants of each treatment, the diameter at the collar was measured with a caliper every 15 days in each elementary plot from the 15th day after transplanting.

o **Number of leaves produced**

From the 15th day after transplanting, the number of total leaves produced was counted every 15 days from the 10 plants selected in the sample for each elementary plot.

3.3.4. Data processing

The collected data were entered using Excel spreadsheet software which allowed the elaboration of graphs and tables. The XLSTAT software was used to perform the analysis of variances (ANOVA) and the comparison of means at the 5% significance level using the Newman and Keuls test. It was also used to perform a multivariate analysis (PCA) in order to establish the correlation between the treatments and the studied parameters.

4. Results and discussion

4.1. Results

4.1.1. Height of *Khaya senegalensis* plants

4.1.1.1. Evolution of the average height of the plants according to time

Analysis of Figure 3 indicates a highly significant difference ($p<0.0001$) in the average height of K. senegalensis plants according to the dates of measurement. In fact, the average height of the plants was 7.39 cm at the first measurement (15 DAR), 11.07 cm at the second measurement (30 DAR) and 13.12 cm at the third measurement (45 DAR). Thus, the growth rate of *Khaya senegalensis* plants was greater between the first and second measurements (0.25 cm/day) than between the second and third measurements (0.13 cm/day).

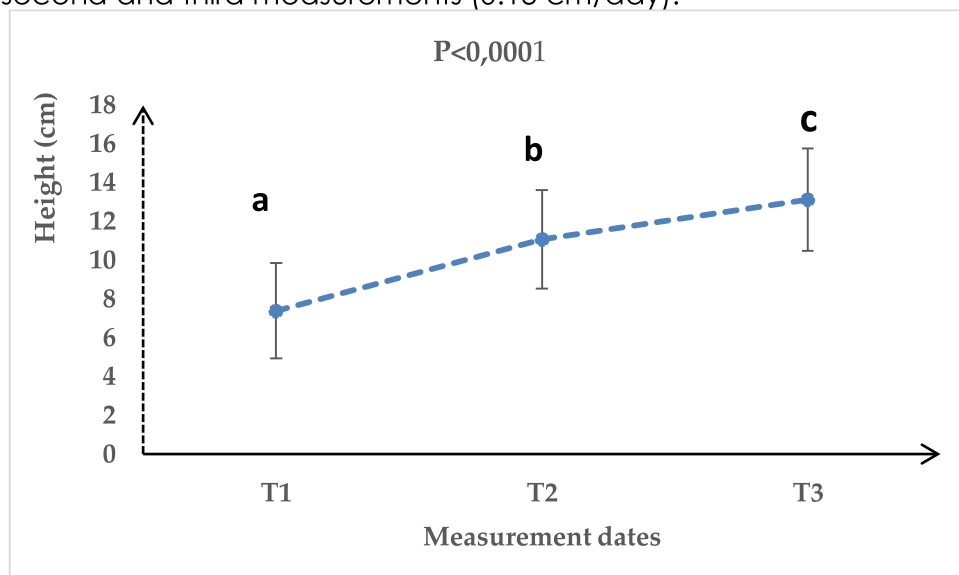

Figure 3: Evolution of *Khaya senegalensis* plants height according to the measurement dates
Legend: T1=15 days after transplanting; T2=30 days after transplanting and T3=45 days after transplanting

4.1.1.2. Effect of treatments on plant height

There was a very highly significant difference in mean plant height ($p<0.0001$) between the different treatments applied (Figure 4). The highest mean plant heights were recorded with the compost (C) and sand+compost (SC) treatments, which gave respective heights of 12.71 cm and 12.25 cm. The lowest average heights (6.7 cm) were observed with sand (S) and sand mixed with potting soil (ST) with heights of 6.7 cm and 8.91 cm respectively.

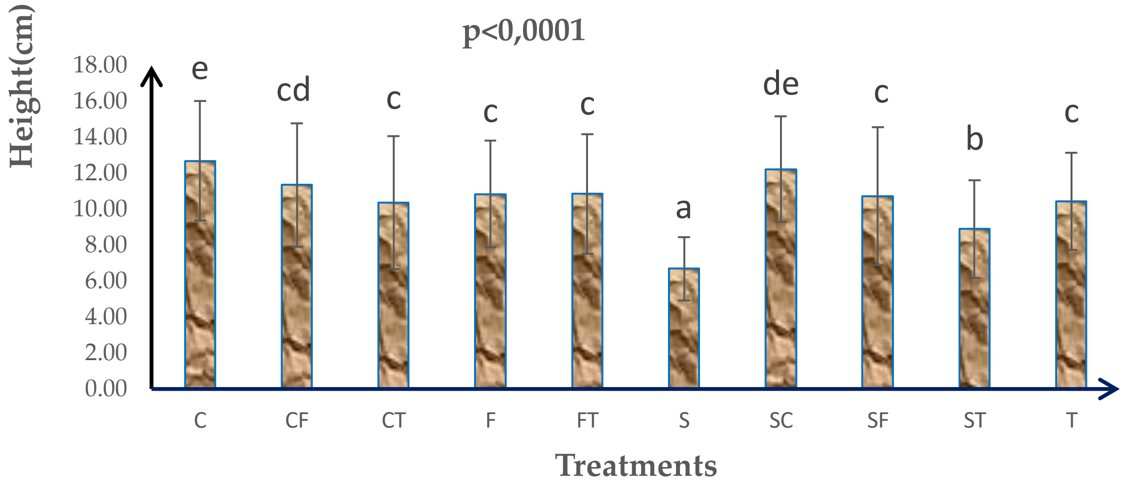

Figure 4: Effect of treatments on plant height

4.1.1.3. Influence of treatments on plant height according to measurement dates

Regardless of the date of measurement, there was a highly significant effect of the treatment factor on the average height of *Khaya senegalensis* plants (Table 1). At the first measurement (15 DAR), the sand+compost substrate (SC) gave the best result (9.26±2.04 cm). While at the 2nd and 3rd measurements, the best results are noted on the compost substrate (C) with 13.66±1.66 cm and 15.33±2.11cm respectively. And whatever the date of measurement, the lowest plant height is recorded with the sand substrate.

Table 1: variation of the plants height (cm) according to the treatments and the measurement dates

	Measurement dates		
Treatments	**T1**	**T2**	**T3**
C	7,72±2,45a	13,66±1,66a	15,33±2,11a
CF	7,37±2,23ab	12,2±0,86ab	14,55±1,54ab
CT	6,27±1,94ab	11±2,40bc	13,9±1,29ab
F	7,72±2,41ab	11,45±1,07ab	13,4±1,73ab
FT	7,37±2,23ab	12,68±2,19abc	13,8±1,49ab
S	5,67±1,78b	6,74±1,58d	7,73±1,37d
SC	9,26±2,04a	12,68±2,07ab	14,8±1,42ab
SF	6,62±3,10ab	11,75±1,84ab	13,85±1,92ab
ST	6,42±2,18ab	9,22±2,19c	11,1±1,37c
T	8,04±2,24ab	10,55±1,66bc	12,75±1,84b
P. value	0,0001	0,0001	0,0001

4.1.2. *Khaya senegalensis* plants collar diameter

4.1.2.1. Evolution of plants collar diameter as a function of time

Khaya senegalensis plants collar diameter increased progressively with time. It increased from 0.2; 0.33 to 0.45 cm at the first, second and third measurement dates respectively (Figure 5). The rate of growth of crown diameter between the first and second measurement dates and between the second and third measurement dates remained the same (0.006 cm/day).

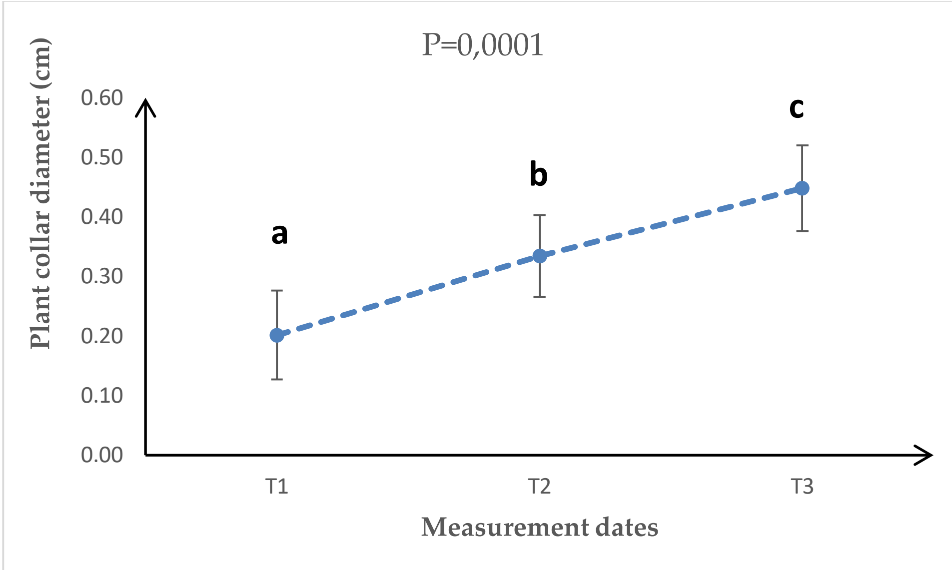

Figure 5: Evolution of plants collar diameter as relation to time

4.1.2.2. Effect of treatments on the plants collar diameter

The treatment factor induced a very highly significant difference ($p<0.0001$) on the plants collar diameter. Overall, the plants collar diameter was greater with the sand+compost substrate (0.38 cm) followed by the manure+soil substrate (0.37 cm. The smallest plants collar diameter (0.25 cm) was observed with the sand substrate (Figure 6).

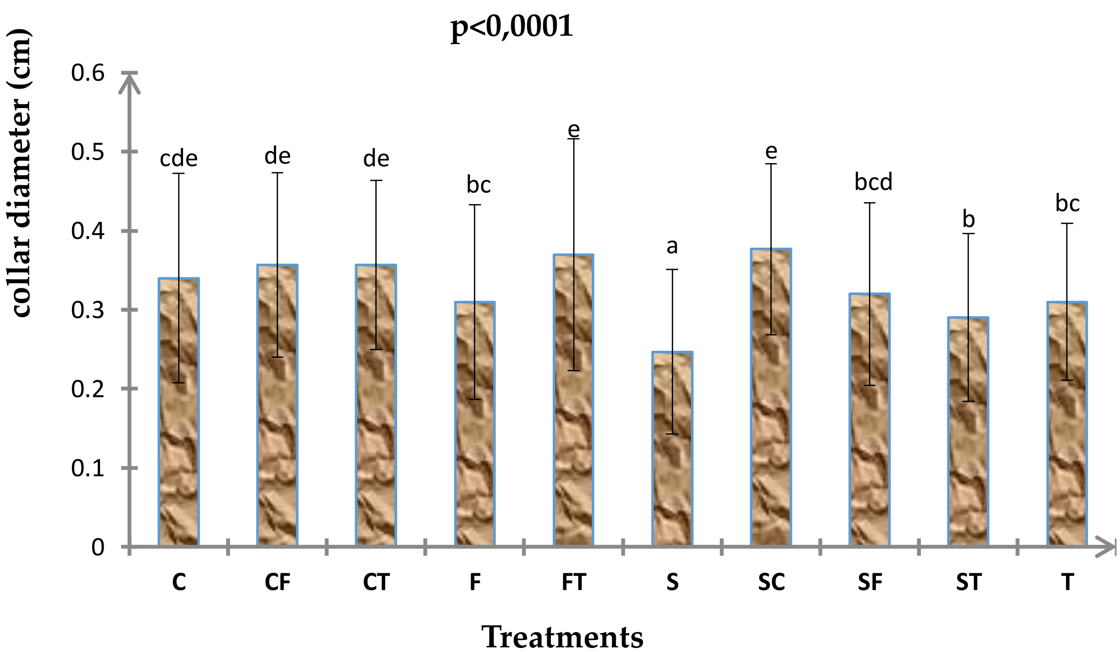

Figure 6: Effect of treatments on plants collar diameter

4.1.2.3. Influence of treatments on plants collar diameter according to measurement dates

Regardless of the date of measurement, the type of substrate induced a very highly significant effect on the average diameter at the crown of the plants (Table 2).

At the first measurement, the largest collar diameter was obtained with the compost+soil substrate (0.23±0.08 cm). This value is statistically different from that obtained with the sand substrate (0.13±0.04 cm) but does not show a significant difference compared to the other

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treatments (Table 2). At the second measurement, the largest diameter at the collar was noted with the sand+compost substrate (0.39±0.07 cm). This diameter is significantly larger than that obtained with the sand substrate (0.25±0.05 cm) and with the sand+soil substrate (0.29±0.06 cm) but does not show a significant difference compared to the other treatments. In the third measurement, the manure+soil substrate (FT) gave the largest diameter at the collar (0.54±0.05 cm). Except for the treatments (substrates) compost+manure (0.48±0.04 cm); compost+soil (0.48±0.04 cm) and sand+compost (0.48±0.08 cm), the average diameter at the collar of the seedlings obtained with manure+compost was significantly larger than that obtained with the other treatments (Table 2).

Table 2: variation of plants collar diameter (cm) according to the treatments and the measurement dates

	Measurement dates		
Treatments	T1	T2	T3
C	0,19±0,10ab	0,36±0,05ab	0,47±0,05b
CF	0,22±0,06ab	0,37±0,05ab	0,48±0,04ab
CT	0,23±0,08a	0,36±0,05ab	0,48±0,04ab
F	0,18±0,09ab	0,33±0,07ab	0,42±0,06bcd
FT	0,22±0,06ab	0,35±0,07ab	0,54±0,05a
S	0,13±0,04b	0,25±0,05c	0,36±0,05d
SC	0,22±0,05a	0,39±0,07a	0,48±0,08ab
SF	0,2±0,07ab	0,33±0,07ab	0,43±0,07bc
ST	0,18±0,06ab	0,29±0,06bc	0,4±0,05cd
T	0,2±0,05ab	0,31±0,03abc	0,42±0,04bcd
P. value	<0,0001	<0,0001	<0,0001

4.1.3. *Khaya senegalensis* plants leaves production

4.1.3.1. Effect of treatments on the number of leaves produced per plant

The type of treatment induced a very highly significant difference (p<0.0001) on the number of leaves produced per plant (Figure 7). Indeed, the treatments that had the greatest influence on leaf production were: compost (6.77 leaves/plant), compost + manure (6.73 leaves/plant), sand + compost (6.67 leaves/plant) and sand + manure (6.5 leaves/plant). The lowest leaf production was noted on the sand substrate alone (4.6 leaves/plant).

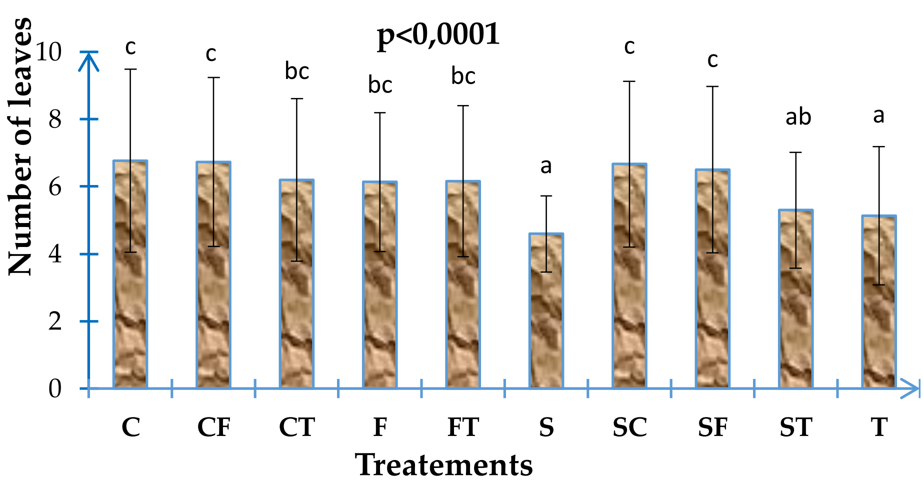

Figure 7: variation in the number of leaves produced per plant according to the treatments

4.1.3.2. Influence of treatments on the number of leaves produced per plant according to measurement dates

The treatment factor induced a very highly significant effect ($p<0.0001$) on leaf production at the second and third measurement (Table 3). However, no significant effect of treatment was observed at the first measurement ($P=0.85$). At the second measurement, the treatments that induced the best leaf production were the substrates compost (8.3±1.25 leaves/plant), compost + manure (8.3±1.34 leaves/plant) and sand + manure (8.4±1.51 leaves/plant). The lowest leaf production was recorded with the sand substrate (5.3±0.95 leaves/plant). At the third measurement, the compost (8.6±1.51 leaves/plant) and sand + compost (8.6±1.96 leaves/plant) substrates gave the best results (Table 3). The lowest leaf production at this measurement date was noted with the sand substrate alone (8.6±1.96 leaves/plant).

Table 3: Variation in the number of leaves produced per plant according to the treatments and measurement dates

	Measurement dates		
Treatements	**T1**	**T2**	**T3**
C	3,4±0,97a	8,3±1,25a	8,6±1,51d
CF	3,6±0,84a	8,3±1,34a	8,3±1,16cd
CT	3,4±0,70a	6,9±1,60ab	8,3±1,25cd
F	4±1,15a	7,1±1,45ab	7,3±1,64bcd
FT	3,6±0,84a	7,6±1,07ab	7,3±1,83bcd
S	3,8±0,92a	5,3±0,95c	4,7±1,06a
SC	4±0,94a	7,4±1,51ab	8,6±1,96d
SF	4±1,25a	8,4±1,51a	7,1±2,13bc
ST	3,8±1,14a	5,9±1,52bc	6,2±1,48b
T	3,8±1,23a	5,2±2,20c	6,4±1,84b
P. value	<0,85	<0,0001	<0,0001

4.1.4. Correlation between the tested treatments and *Khaya senegalensis* growth and development parameters

It appears from Table 4 that the two axes (F1 and F2) absorb almost all the information with eigenvalues of 2.69 and 6.41 bits respectively. These two axes represent respectively 89.8 and 6.4% of inertia, that is to say a cumulative inertia of 96.22%. The factorial plane constituted by these two axes F1 x F2 thus allows a very good representation of the information contained in the matrix.

Table 4: Distribution of eigenvalues and inertia along the factorial axes of the Principal Component Analysis (PCA)

	F1	F2	F3
eigenvalues	2,694	0,19	0,11
inertia (%)	89,81	6,41	3,78
Cumulative inertia (%)	89,81	96,22	100

Principal component analysis was performed on the basis of the 10 treatments tested and the 3 growth parameters of *Khaya senegalensis* (Figure 8). This PCA made it possible to discriminate three groups of treatments:

- Group A consists of treatments C, F, SF and CF located on the side of the positive abscissa and represents the treatments that influence more the height and leaf production of *Khaya senegalensis* plants.
- Group B consists of treatments S, ST and T located opposite group A and which do not effectively stimulate the growth of *Khaya senegalensis* plants.
- Group C consists of treatments CT, FT and SC and represents the treatments that have a greater influence on the crown diameter of *Khaya senegalensis* plants.

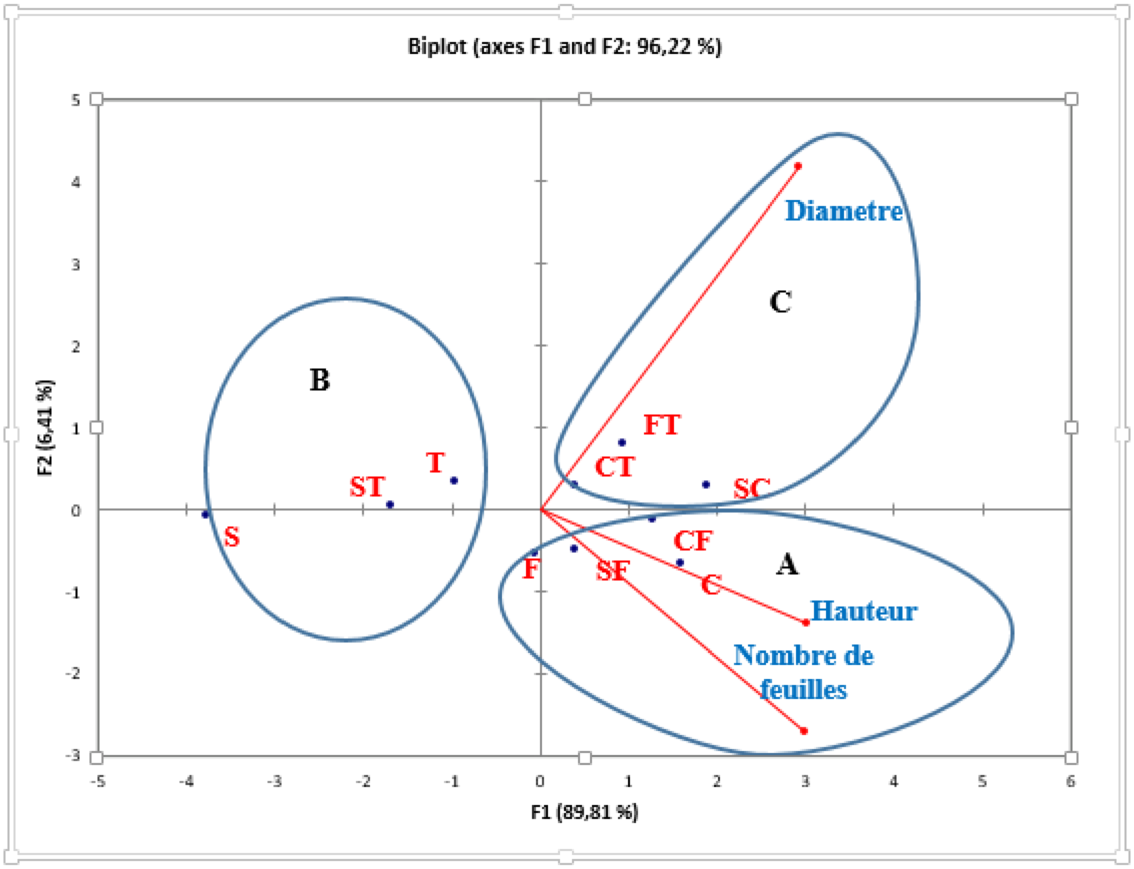

Figure 8: Distribution of the tested treatments according to their influence on *Khaya senegalensis* plants growth parameters

5. Discussion

The purpose of this study is to evaluate the effect of different substrate combinations on the growth and development of *Khaya senegalensis* seedlings. This was done in order to contribute to the rapid reconstitution of natural stands of the species. The study showed that substrates made of organic amendments favored the growth of *Khaya senegalensis* plants. Indeed, supplemental fertilization is necessary to increase growth and promote development in the nursery of the species as stated by Soltner (2000). According to this author, the organic matter, by releasing the mineral elements it contains, allows the feeding of the plants. Indeed, the best results on height and leaf production are recorded with the compost treatment. As for the diameter at the collar of the plants, it is more influenced by the combination sand+compost followed by the combination manure+soil. The good performances recorded on the height and leaf production with the plants amended with compost could be explained by the richness of this amendment in nutritive elements and the fast release of these last ones in the soil. But also by its contribution to the improvement of the physical properties of the soil. Indeed, according to Soudi (2001) cited by Nanema (2007), in addition to the effect of organic manure on the improvement of the physical and biological conditions of the soil, it provides the soil with major nutrients. The same author states that the nutrients that can be provided are variable and depend on the composition of the compost used, the dose and the hydric and thermal conditions of the soil. Also, the sand+compost (SC) and manure+soil (FT) treatments gave the highest values in terms of crown diameter of Khaya senegalensis plants. In addition, Soltner, (2000) cited by Savadogo, (2011) showed that the good growth of plants and their resistance to various aggressions (parasitism for example), result not only from a good supply of elements N, P, K, but also from a sufficient availability of secondary elements and trace elements (Fe, Mn, Cu, Zn, Bo, Mb) and various activators. According to the same author, humus favors the supply of trace elements to plants and provides growth activators that act at very low doses. This confirms the observations of Duthil (1973) cited by Kabore (2004) according to which the decomposition of organic matter is progressive and doubly interesting:

- on the one hand, it is spread over almost the entire vegetation period, which corresponds well to the concern of a regular and continuous feeding of the plants;
- on the other hand, it appears complete in the sense that the microbial destruction of the buried plant debris releases N, P, K, Ca, S as well as other less known elements such as Mg, Zn, B, Cu, Fe, etc., all of which are useful for the growth of the plants.

On the other hand, sand alone gave the lowest performance for all the growth parameters studied. This result could be related to a very low nutrient content of this substrate but to its low retention capacity.

Our results showed that sand alone, potting soil alone or the combination of both substrates did not significantly improve the growth of *Khaya senegalensis*. This shows the importance of organic matter in improving the growth and development of *Khaya senegalensis* plants. These results are in line with Bonzi's (1989) statement that vegetative biomass increased with the application of organic manure.

6. Conclusion and perspectives

This study was conducted to provide information for rapid production of *Khaya senegalensis* seedlings in nurseries with a view to restoring stands of this species through reforestation.

The results of this study showed that the contribution of organic amendments (compost, manure and potting soil) has a significant influence on the growth parameters of *Khaya Senegalensis*.

It appeared that the height of *Khaya senegalensis* plants and the number of leaves produced per plant were more influenced by compost alone while the diameter at the collar of the plants was more influenced by the combination of sand + compost.

The poorest performances in terms of growth of *Khaya senegalensis* plants (height, diameter at the collar and number of leaves produced per plant) are recorded with sand alone, potting soil alone or the combination of sand and potting soil.

However, it seems appropriate to continue the studies by evaluating the effect of different pre-treatments of *Khaya senegalensis* seeds on their germination rate and speed.

Conflict of Interest: The authors declare no conflict of interest.

REFERENCES

Adjahossou, S. G. C., Yaoitcha, A., Houehanou, D. T., Gouwakinnou, G. N., Sode, A. I., Houinato, M., & Sinsin B. (2018). Habitats favorables de conservation de *Khaya senegalensis* au Bénin. *Fiches Techniques*. Bibliothèque nationale, Bénin, 12 p.

Adomou, C. A. (2005). Vegetation patterns and environmental gradients in Benin.Implications for biogeography and conservation.PhD thesis Wageningen University, Wageningen. 136p.

Bamba, N. (2018). Effet de cinq prétraitements sur la germination du vène (*Pterocarpus erinaceus* Poir., *Fabaceae*) dans la Reserve du Haut Bandama (Côte d'Ivoire) .*Eropean Scientific Journal*, p : 439-440.

Bonzi, M. (1989). Etudes des techniques de compostage et évaluation de la qualité des composts: effets des matières organiques sur les cultures et la fertilité du sol. Mémoire de fin d'études ISN/IDR. Université de Ouagadougou, 66 p.

Charahabil, M.M. Ndiaye, S.et Diatta, M. (2017). Caractérisation des Plantations à base d'anacardier (*Anacardium occidentale* L.) dans le Balantacounda: cas des communes de Kaour, Goudomp et Djibanar (Casamance/Sénégal). *European Scientific Journal*.p246

Douma, S., Adamou, M. M., Aboubacar, K., Alleidi, I. & Boubacar, A. N. (2019). Effet du régime d'irrigation sur la germination et la croissance en pépinière de Parkia biglobosa (Jacq.) G. Don. *Journal of Animal &Plant Sciences*, 40(1) : 6573-6583.

Enda Pronat. (2017). Agroforesterie Et Arboriculture (Faoune, Casamance). Fiche réalisée par: pronat@endatiersmonde.org.p1

Ehui, S. K. & Hertel, T. W. (1989). Deforestation and agricultural productivity in the Côte d'Ivoire. *American Journal of Agricultural Economics*, 71(3): 703-711.

Hargitt, D.L. (1994). Conservation of biodiversity: Corridors, an alternative to fragmented ecosystems? Msc Thesis. VrijeUniversiteitBrussel, Belgique.65 p.

Hilton-Taylor. (2000). UICN red list of threatened species. UICN, Gland, Switzerland and Cambridge, UK. 61p.

ISRA. (1993). Rapport n°19934997, Directions des recherches sur les productions forestières, Dakar (Sénégal) 23p.

Kabore, W.T. T. (2004). Impact de l'apport des déchets urbains solides non triés sur les potentialités agronomiques des sols: Cas de l'agriculture péri-urbaine de Ouagadougou. Mémoire d'Ingénieur du Développement Rural. Université Polytechnique de Bobo-Dioulasso (UPB). Institut du Développement Rural (IDR), 91 p.

McNeely, J.A. (1996). Conservation and future: Trends and options toward the year 2025. A discussion paper.Iucn, Gland Switzerland. 66 p.

Nanema, S.L. (2007). Evaluation de l'efficacité agronomique du compost de déchets urbains solides de la ville de Bobo-Dioulasso. Mémoire d'Ingénieur de l'Institut Polytechnique Rural de Formation et de Recherche Appliquée (IPR/IFRA) de Katibougou. 68 p.

Olivier, M., Zerbo, P., Boussim, J. I. & Guinko, S. (2012). Les plantes des ripicoles forestières à usage traditionnel par les tradipraticiens de santé et les chasseurs Dozo Sénoufo du Burkina Faso. International Journal of Biological and Chemical Sciences, 6(5) : 2170- 2191.

Sala, E. Ballesteros, E. Starr, R.M. (2001). Rapid decline of Nassau grouper spawning aggregations in Belize: fishery management and conservation needs, 26-23–30

Sanogo, S., Sacandé, M., Damme, P. V. & NDiaye, I. (2013). Caractérisation, germination et conservation des graines de *Carapa procera* DC. (Meliaceae), une espèce utile en santé humaine et animale. *Biotechnology, Agronomy, Society and Environment*, 17(2) : 321-331.

Savadogo, I. (2011). Evaluation de l'efficacité agronomique du compost de déchets urbains solides de la ville de Bobo-Dioulasso. Mémoire d'Ingénieur d'Université Polytechnique de BOBO-DIOULASSO. Institut du Développement Rural. 42 p.

Soltner, D. (2000). Les bases de la production végétale, Tome I, Le sol et son amélioration. Collection Sciences et techniques agricoles, 472 P., (PP 13-16).

Von Maydell, L H.J. (1983). Arbres et arbustes du sahel: leurs caractéristiques et leurs utilisations. *Eshborn*, pp 282-284.

Wezel, A. (2006). Woody vegetation in Sahelian West Africa: evidence from local knowledge. *Environ Dev Sustain*, 8: 553-567.